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The Wheat Midge in the Pacific Northwest

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SUMMARY

The wheat midge (*Sitodiplosis mosellana* (Gehin)) was first reported in 1904 from the Chilliwack district in the Fraser River Valley of British Columbia. Apparently it spread from there into Whatcom County in northwestern Washington, where it has caused injury to spring wheat since 1912. In 40 years the midge has spread southward 180 miles from its first point of introduction into the Pacific Northwest.

Damage to the grain is caused by the larvae of the midge feeding on the developing kernels. When feeding on wheat, barley, and rye, the larvae are able to mature in about 2 weeks. They then descend to the ground and form cocoons in the soil, where they pass the winter. The adult flies emerge the latter part of June or early in July, and oviposit on the wheat heads during the period between the first emergence of the head from the boot and the completion of blossoming. Egg laying takes place only late in the afternoon and in the evening. The eggs are usually laid in clusters in grooves on the spikelets or under the glumes, and they hatch in 5 to 7 days.

A mite, *Atomus pilosus* Banks, was found destroying many eggs in the bottom-land fields, and a small hymenopteron, *Inostemma horni* Ashm., was observed ovipositing in eggs of the midge.

Fall-sown wheat was not injured by the midge, and spring wheat seeded by the first week in April usually escaped serious injury. On

[1] The work reported in this paper was carried on under the direction of L. P. Rockwood, whose assistance and advice is gratefully acknowledged. The writer also wishes to thank Alan G. Dustan, of Field Crop Insect Investigations, Division of Entomology, Department of Agriculture of the Dominion of Canada, for permission to refer to the unpublished work of the late R. C. Treherne; also R. Glendenning, of the Dominion Entomological Laboratory, Agassiz, B. C., for his kindness in furnishing data, with permission to use it.

low, wet, peat land either fall- or spring-sown wheat was slow in maturing and was severely injured. The stubble of infested wheat should be plowed under, if possible, before overwintered midges emerge late in June. New sowings of spring wheat should be as far as possible from the stubble of wheat that was infested the previous year and will remain unplowed because it was seeded to grass and clover.

INTRODUCTION

This circular is based mainly on investigations of the wheat midge (*Sitodiplosis mosellana* (Gehin)), carried on during the wheat-growing seasons of 1921–24. The studies were made in the vicinity of Lynden, in the extreme northwest corner of Washington. Apparently this foreign species entered northwestern Washington from British Columbia, where its presence was first reported in 1904. Some additional information has been obtained since 1924 from surveys made every 2 or 3 years to check on the natural spread of the midge southward into uninfested territory. The advance of the midge eastward has been retarded by the natural barrier afforded by the Cascade Mountains. Its spread southward has been slow, apparently because its host plants, which are wheat, barley, and rye, are not grown to any extent in western Washington; however, it is probable that the midge will eventually reach the more important wheat-growing area of the Willamette Valley, in Oregon. If it does reach this area and if it increases in importance as might be expected, information on its identity, habits, and control will be needed immediately. This circular has been prepared to meet such a need.

DISTRIBUTION OF THE MIDGE

The presence of and injury by the wheat midge in the Pacific Northwest were first reported in 1904 [2] from the Chilliwack district in the Fraser River Valley of British Columbia. In 1905 a bad attack by the wheat midge nearly destroyed the crop on the experimental farms at Agassiz, British Columbia, where small plots of 28 varieties of spring wheat were seeded on April 18.[3] That same year injury to wheat over most of the lower Fraser River Valley was so severe that many fields were not cut, but were harvested by pigs. From 1905 to the present time more or less injury has resulted whenever the growing of spring wheat has been attempted. In 1937 Provincial Entomologist Max H. Ruhmann [4] reported that the wheat midge severely injured a wheatfield near Lumby, in British Columbia. This is the first report of the occurrence of the midge in an Okanagan district, and the only report of its spread east of the Cascade Mountains.

From British Columbia the midge soon spread into Whatcom County, in northwestern Washington, where it was reported by farmers to have caused severe injury to spring wheat in 1912. A

[2] FLETCHER, J. REPORT OF THE ENTOMOLOGIST AND BOTANIST. Canada Expt. Farms, Ent. and Bot. Rpt. 1904: 205–256, illus. 1905.

[3] SHARPE, T. A. REPORT OF SUPERINTENDENT OF EXPERIMENTAL FARM FOR BRITISH COLUMBIA. Canada Expt. Farms, Agassiz (B. C.) Farm. Rpt. Sup. 1905: 401–438, illus. 1906.

[4] RUHMANN, M. H. REPORT OF PROVINCIAL ENTOMOLOGIST. Brit. Columbia Dept. Agr., Ann. Rpt. (1936)31: 46–47. 1937.

mountainous and timbered strip of land retarded the advance of the midge south of Whatcom County until 1923, when it was found to be well distributed in western Skagit County and as far south as Silvana in Snohomish County. By 1930 it had reached Fall City, in King County, and in 1936 was found at Puyallup and Orting, in Pierce County. Surveys south of these points in 1939 and 1941 did not show an increase in the area known to be infested. The slowness of spread, which has covered only 180 miles in 40 years, has apparently been due to large areas of mountainous, timbered, and waste lands, which served as natural barriers, and to the fact that little wheat is grown in this area. The survey of 1939 took in Fidalgo and Whidbey Islands, but, as in former visits, no evidence of the midge was found, although parts of these islands are separated by fairly short distances from infested areas on the mainland. Little wheat is grown on Fidalgo Island. The fact that rainfall is much less than on the adjacent mainland may be a factor inhibiting the development of the midge on Whidbey Island.

FOOD PLANTS

The larva of the wheat midge is able to complete its development on the kernels of wheat, barley, and rye. Very little barley or rye was grown in the infested area while the studies were being carried on, and most of the observations were made on wheat. On the few farms where wheat and barley or wheat and rye were growing close together, the midges preferred to oviposit in the wheat heads. Where two varieties of barley were growing across the road from each other, one had a kernel infestation of approximately 1.3 percent and the other an infestation of 14.5 percent. This variation in the susceptibility of different varieties of barley was confirmed by Canadian reports [5] that in 1912 the infestation in different varieties of barley ranged from none to 49.9 percent. In the investigations in Washington this varietal difference was not observed in wheat. In fields of mixed wheats and on the three spring varieties Early Baart, Marquis, and Hard Federation, which were used in experimental plots, no significant difference in susceptibility was noted. No infestation was found on oats or grasses.

CHARACTER OF INJURY

The injury to grain is done by the feeding of the tiny larvae of the midge on the developing kernels. If 1 larva attacks a kernel at the time it is beginning to form, a large shriveled place will result when the kernel is mature. When 3 to 4 larvae are present the kernel will be completely destroyed. As many as 11 full-grown larvae were found on a single dried and shrunken kernel of wheat and 17 immature larvae were seen on one immature kernel. Winter- or fall-seeded wheat was found to be little injured, owing to the comparative maturity of the kernels when the midges began to emerge from the soil in the spring. In spring-seeded wheat, infestations as high as 100 percent of the heads and 52 percent of the kernels, with 40 percent of the kernels totally destroyed, were found.

[5] Unpublished data furnished by R. C. Treherne.

GENERAL DESCRIPTION

The eggs of the wheat midge are laid singly or in clusters in grooves on the wheat heads and are barely visible to the unaided eye. They are cylindrical, elongate, and when first laid are a uniform pale yellow, but after they begin to incubate, about the second day, reddish spots appear. The newly hatched larva, except for the faint lines of segmentation, is similar to the egg from which it came. When examined as it is lying against the developing kernel, the larva is first seen as watery white but as it grows older it gradually turns yellow; this color deepens in intensity until at maturity it is orange yellow. The cocoon is about the size of a mustard or turnip seed. It appears gray but is usually covered or interwoven with particles of soil, so that it closely resembles a grain of earth. This cocoon with its covering of earth is very difficult to find or to separate from the soil. The pupal stage was not observed. The adult female is a fragile mosquitolike fly about one-third the size of a mosquito. The body is a delicate salmon pink. The head is light brown except for the jet-black eyes, which take up most of its surface. The legs are light brown and the antennae dark brown. The wings are dusky and fringed with hairs. The abdomen is equipped with a long extensible ovipositer. The male midge is smaller than the female, its body is more slender and duller in shade, and the tip of the abdomen terminates in a turned-up pair of clasping organs used in mating.

SEASONAL ACTIVITY

Wheat midges pass the winter as larvae in tiny cocoons in the soil. From these cocoons the adult midges begin to emerge shortly after the middle of June. They are numerous in the fields from the last week in June to the middle of July. After the middle of July there is a rapid decline in numbers, but generally a few are present up to the end of the month.

Mating is not easily observed in the field but it probably takes place soon after emergence, as a pair were seen to mate in an emergence cage the same day they came out of the soil. The males rarely migrate far from the fields in which they emerge; therefore, in sweeping with an insect-collecting net in wheatfields not previously infested, practically all the midges caught were females. By sweeping where emergence took place, more nearly the same proportions of females and males were caught.

As the wheat matures in a field, the adult midges usually leave in search of other fields where the heads are younger. Just how far the midges will fly after emergence or when migrating from nearly mature fields is not known, but since midges were more concentrated in the edges of fields where wheat had been newly planted next to old wheat stubble, and since similar wheatfields some distance from wheat stubble are noticeably less infested, it appears that most of the adults do not migrate far. This seemed to be borne out in the dry year of 1922, when few midges emerged except in some low, wet, bottom fields, and but few of these migrated to nearby upland fields. During the day the midges remain close to the ground around the base of the grain stalks. At sundown, or a little before in the shady parts of the field, the females fly up to the heads and begin laying

eggs. Egg laying takes place only late in the afternoon, from about sundown until dark, and no egglaying was observed in the daytime on damp, cloudy days, as was reported by Fitch[6] for the State of New York. Observations at night and before sunrise in the morning showed many females resting on the wheat heads but none were laying eggs, and by sunup the females had returned to the bases of the wheat plants. On otherwise favorable evenings no eggs were laid when a stiff breeze was blowing. The motion of the wheat heads either confused the midges or the moving heads offered too hazardous a place to alight. There was also very little egg laying on evenings with continuous rainfall. The most favorable times for egg laying were evenings that were still and warm. On such evenings sometimes as many as 4 or 5 midges were seen ovipositing on the same wheat head.

The midges prefer to oviposit on the grain heads from the time when the heads are just emerging from the sheath to the end of the blossoming period. In wheatfields where the heads are well advanced the midges will often concentrate on the wheat heading later in low, wet spots in the field, and a good many eggs will be laid on late, stunted heads. Such heads are often found to be infested in fields of winter wheat, where most of the normal heads escaped infestation because of advanced development at the time the midges were laying eggs. In the absence of more suitable heads, however, some midges will oviposit on more advanced heads having kernels nearly full-grown. Such kernels suffer little or no injury, and it is doubtful whether the larvae that hatch from these eggs ever reach maturity.

The females begin to lay eggs within a few days after emergence. The eggs are sometimes laid singly but more often in clusters. Some clusters contain as many as 14 eggs. Although the eggs may be laid on all parts of the developing head, the midges prefer to place them just under the edge of a glume or in the groove where the spikelet lies against the rachis. Some female midges, collected in the field, placed in lantern-chimney cages, and supplied with fresh, young wheat heads, laid 80 to 90 eggs each, and one laid 118, in 12 days. In a similar cage the female of a pair taken from an emergence cage laid 133 eggs in 8 days.

The eggs hatch in 5 to 7 days. The larva crawls down on the ovary of the wheat and begins to feed. It matures about 2 weeks after hatching. Allowing approximately 1 week for the egg to hatch, the entire period from egg to mature larva is about 3 weeks. Fitch[6] states (*pp. 51–52*) that in New York the larva leaves the wheat head and descends to the ground after maturing, provided the straw is wet enough so that it can crawl down, but if no moisture is present the larva remains on the kernel, where it gradually shrinks away from its outer skin, although remaining inside it. With the next rainfall the encased larva crawls out of this skin and out of the wheat head, leaving the cast skin behind. Although these activities were not fully observed at Lynden, Wash., the mature larva appeared to follow this behavior.

After descending to the ground, the larva spins itself up in a tiny

[6] FITCH, A. REPORTS ON THE NOXIOUS, BENEFICIAL, AND OTHER INSECTS OF THE STATE OF NEW YORK. Rpt. on the Noxious, Beneficial, and Other Insects, N. Y. State 6: [3]–126, illus. 1865.

cocoon in the soil, to pass the winter and await favorable weather for pupation and emergence the following spring. If the spring is dry and unfavorable for emergence the larva will remain in the cocoon until a more favorable spring. This failure to emerge until the second season was observed in a jar of earth containing cocooned larvae that was left in the laboratory and moistened occasionally. Midge larvae placed in the jar in the fall of 1922 produced some adults in the spring of 1923 and others in the spring of 1924. This diapause was also noted in a box of earth taken from a heavily infested wheatfield in the spring of 1921 and stored under shelter until June 28. It was then placed outdoors in a screened box and kept moist. Few if any midges emerged from this earth in 1922; but in 1923 this same box of earth, which had been left undisturbed in the open, was found to be producing midges. It was therefore screened again and many adult midges were obtained from it. One field that had been in wheat in 1921 was not plowed because grass had been seeded in the wheat. A hay crop was harvested from it in the dry season of 1922 and few adult midges were present. In 1923, when this field was being lightly pastured, a large number of male and female midges were swept from the grass. The fact that male midges have been found in numbers only in proximity to the places where they have emerged would indicate that the midge larvae produced in 1921 remained quiescent during the dry season of 1922 and produced adults in 1923.

Although not recognizing the cause, Fitch [6] reported [7] (*pp. 22–23*) that in New York in 1852 and 1853, with dry Junes, the midge nearly vanished from the fields; therefore the farmers thought they could sow wheat without fear of injury; then in 1854, when May and June were wet, it became destructive and infestation was so severe that the damage in New York State was estimated at 15 million dollars. Apparently the loss was caused by a large number of midges carried over in the soil for 2 years. It thus appears probable that with continuous dry seasons during the time of normal midge emergence the larvae will remain inactive in the cocoons for 2 or more years, and with the coming of another wet season will produce normal individuals.

The abundance of midges, with their subsequent damage, is closely related to rainfall during and shortly before the normal emergence time of the flies. The climate around Lynden, Wash., is cool, with copious winter rains and usually with adequate moisture in the spring and early part of the summer. When the weather late in May and in June is dry, few midges are present and injury is negligible, but when there is abundant rainfall in June midges are numerous and injury to late-maturing wheat is severe. The amount of rainfall in May, June, and July varies considerably from year to year. In 1921 June was very wet, with 3.79 inches of rainfall during the month. Midges were very numerous that season. The season of 1922 was very dry, with only 0.05 inch of rainfall from May 25 through July, and midges were very scarce. In 1923 May was wet, with 3.11 inches of rainfall and from June 1 to 14 the rainfall amounted to 1.52 inches. That season midges were again moderately abundant. In 1924 May was very dry, with only 0.08 inch of rainfall, and 1.46 inches of rain fell from June 6 to 18. The latter half of July was

wet, with 1.20 inches of rainfall between the 14th and the 28th.[7] That season midges were again rather scarce.

This dependence on adequate moisture in the spring and early part of the summer will probably prevent the midge from ever becoming a pest in the arid districts east of the Cascade Mountains, except possibly in irrigated sections. In the uninfested parts of western Washington the midge can be expected to cause severe injury to spring wheat in wet seasons, and it will undoubtedly cause as severe if not greater injury in the more general wheat-growing area of the Willamette Valley, in western Oregon, when it arrives there. Wheat has never ranked as a major crop in the area of Washington now infested, partly because of the presence of the midge but mainly owing to the limited acreage available for wheat growing and to the fact that other crops have usually proved more profitable.

No fall emergence was noted in Washington and some evidence was obtained to indicate that when moisture is supplied during the latter part of a dry spring it will not cause the larvae to pupate and emerge after the normal season for these activities has passed.

ENEMIES OF THE MIDGE

Small red mites, *Atomus pilosus* (Banks),[8] were numerous on some bottom-land fields and were found to be destroying exposed midge eggs. The mites were very active, running up and down the plant stems and around on the leaves.

A small hymenopteron, *Inostemma horni* Ashm.,[9] was found to be seeking and apparently ovipositing in midge eggs. This insect was very tame and could be easily observed with a hand lens. A number of females were observed with the ovipositor inserted in exposed eggs, and others were seen with the ovipositor inserted under the outer glume of the wheat kernel on which a cluster of midge eggs was placed. The adults were active during the day, and late in the evening were found hiding in crevices of the wheat heads. Apparently they were parasites, but were rather scarce in most fields. Rearing of the parasites was not attempted, as the investigation was discontinued late in the summer during which these observations were made. No other parasites or predators were observed.

CONTROL

Winter- or fall-seeded wheat was found to be little injured, because it matures too early to be attractive to the midges or suitable for the development of the larvae. Where local conditions will permit, and where injury by the wheat midge is to be expected, winter- or fall-seeded wheat should be grown in preference to spring wheat.

Since fall-seeded wheat was little injured, because it matures early, it might be assumed that the early seeding of a quickly maturing variety of spring wheat would greatly lessen the amount of injury by the midge. Observations on planted fields and on experimental wheat plots planted at different dates in 1922, 1923, and 1924 proved this assumption to be true in general. Three varieties of wheat were

[7] These records of rainfall were taken from the U. S. Weather Bureau records for Bellingham, Wash., located 16 miles south of Lynden but in the same general area and apparently receiving about the same amount of rainfall.

[8] Determined by H. E. Ewing.

[9] Determined by A. B. Gahan.

sown—Early Baart, Hard Federation, and Marquis. Owing to unfavorable weather during two of these seasons and to the few and widely scattered wheatfields near Lynden, where the studies were made, these results were not entirely conclusive and should be rechecked when the midge spreads from its present location to the areas in Oregon and Washington where wheat growing is more general. More extensive work with time of seeding of spring wheat to control the midge was carried on by Canadian workers at Agassiz, B. C., in 1929 through 1937, except for the year 1930.[10]

In the 8 years of observation it was found that quickly maturing spring wheat, sown before the flowering of the European varieties of plum, was past the susceptible stage before the principal emergence of the midge took place, and the wheat therefore escaped inqury. The time of flowering of the European plums varied as much as 40 days from season to season, the earliest date being March 14, the latest April 23, and the average for 16 years April 10. Wheat seeded late in May and in June also escaped the midge, but owing to crop failure in dry seasons these seedings were ruled out as a method of midge control.

In the vicinity of Lynden wheat sown by the first week in April was much less injured than that sown between April 8 and May 10. Fields seeded after May 10 also escaped with little infestation, but in dry seasons there is considerable chance of crop failure in late-sown fields.

On low, wet peat land near Lynden either fall- or spring-seeded wheat matured very slowly in the spring. As the midges appeared to be more numerous and injurious on low, wet land, the wheat on these lands was almost sure to suffer some injury, regardless of variety or the time of seeding. In similar locations, where the midge is an important factor, the growing of wheat should not be attempted, but a crop that would be immune to midge attack should be substituted.

In fields where wheat stubble was plowed under and the land was seeded back to wheat the midge did not appear to be more abundant than in wheatfields that had been in other crops the year before. There was some evidence, however, that when these fields were again plowed the following year a considerable number of midges emerged. If this is true, the value of plowing stubble under to control the midge would be reduced; however, the main source of infestation is unplowed wheat stubble. The midge has every chance to pass the winter successfully in undisturbed wheat stubble and emerge the following spring to infest nearby wheatfields. The stubble of infested wheatfields should therefore be plowed under, if possible, before the midges emerge late in June. Fields that have been infested by the wheat midge are often seeded to grass or clover and remain unplowed the following year. New seedings of spring wheat should be located as far as possible from such fields.

[10] Summary of Wheat Midge Project, Agassiz, B. C. 1929–37. Reported by P. Glendenning in personal correspondence.

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